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Phil. Trans. R. Soc. Lond. B 1992 **337**, 127-130
doi: 10.1098/rstb.1992.0088

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Few topics have generated more debate and controversy in the scientific literature over the past few years than the biological and behavioural origins of anatomically 'modern' human populations: i.e. populations belonging to our own form of *Homo sapiens sapiens*. What is common ground in all these debates is that populations that were fundamentally 'modern' in both a basic anatomical sense, and in at least the majority of cultural and behavioural senses, were effectively established throughout all the major regions of the Old World (i.e. Africa, Asia, Europe and parts of Australasia) by at least 30–35 ka ago (1 ka = 1000 years). The current controversy hinges essentially on what happened before this time – above all during the crucial formative phases of modern human development between *ca.* 200 and 30 ka ago. It is this period which forms the major battle ground of current debate over the evolutionary origins and mutual relationships of modern world populations, and which provides the central focus of the present symposium.

Throughout the greater part of the present century – effectively since the discovery of the 'classic' Neanderthal skeleton at La Chapelle-aux-Saints in 1908 – the issue of the biological and demographic origin of modern human populations has been seen very largely as a dichotomy between two sharply opposed schools of thought. One view – frequently referred to in the more popular scientific literature as the 'Garden of Eden' or 'Noah's Ark' hypothesis – asserts that biologically and genetically modern human populations evolved initially in one fairly limited and closely prescribed region of the world and subsequently dispersed – at varying times – to all other regions, either with or without significant degrees of genetic intermixture and interbreeding with the pre-existing populations within the same regions. At various points throughout the present century, and with varying degrees of emphasis, this view has been maintained by (among others) Marcellin Boule, William Howells and F. Clark Howell. More recently, workers such as Günter Bräuer, as well as one of the present authors (e.g. Stringer & Andrews 1988), have focused attention on Africa as the particular continent of origin: the so-called 'Out of Africa' model.

The principal alternative scenario – now generally referred to as the 'multiregional evolution' hypothesis – asserts that there was no such simple or discrete origin for the morphological and genetic characteristics of modern humans, and that human populations in all of the major regions of the Old World (i.e. Africa, Asia and Europe) have pursued an essentially parallel pattern of evolution over at least the greater part of the past million years or so. Central to the latter model, of course, is the assumption that there was a sufficient degree of interbreeding and resulting gene flow between these geographically dispersed populations to maintain a broadly similar pattern of evolutionary development within the different regions throughout the whole of this time range. The principal proponents of this hypothesis have been Ales Hrdlička, Franz Weidenreich, Carleton Coon, Loring Brace and (more recently) Milford Wolpoff and Alan Thorne (e.g. Wolpoff 1989; Thorne & Wolpoff 1992). Potentially one of the most significant points of conflict between these two models relates to the character and timing of the divergence of the modern patterns of regional ('racial') variation among present-day populations. Whereas the population-dispersal hypothesis asserts that all of these divergences are the result of relatively short-term evolutionary processes operating purely over the past 100 ka or so, the multiregional evolution viewpoint would trace these regional divergences back through a much longer timescale of at least several hundred thousand to one million years.

It is hardly possible here to review the ebb and flow of debate between these two conflicting hypotheses over the past 80 years or so. Reviews of the earlier years of this debate have been provided by Frank Spencer (1984), and more recently by Smith *et al.* (1989). What can be said is that over the course of the past 10–15 years, a number of significant developments emerged which appeared to shift the balance of the evidence fairly strongly in favour of the former (population dispersal) scenario. One of these developments was the application of new dating methods. The use of the newly developed dating methods of thermoluminescence (TL) to burnt flint and electron spin resonance (ESR) to tooth enamel associated with the large samples of skeletal remains recovered from the two sites of Mugharet es Skhul and Jebel Qafzeh in northern Israel revealed that these fossils – which had previously been generally assumed to be around 40–50 ka in age – in reality dated to around 100 ka (Grün & Stringer 1991; Aitken & Valladas, this symposium; Schwarcz & Grün, this symposium). Because these fossils had generally been accepted and described in the literature as showing modern features, this appeared to demonstrate that such forms had appeared in at least one region of the world at a much earlier date than suspected hitherto, and demonstrably at a time when much more 'archaic' forms (such as the Neanderthals) were still living in closely adjacent – or even overlapping – areas of Eurasia. Further discoveries seemed to reinforce the same pattern. Thus a number of other finds of essentially 'modern' skeletal remains at sites in southern and eastern Africa (such as Border Cave and Klasies River Mouth in South Africa, and Omo in Ethiopia) appeared to date from around 80–100 ka ago (Rightmire 1989), whereas, by contrast, a typically Neanderthal skeleton from the site of Saint-Césaire in western France was found to date from as recently as *ca.* 35 ka ago (Lévêque & Vandermeersch 1980; Mercier *et al.* 1991). All of these discoveries appeared, on the face of it, to conform much better with the predictions of the population dispersal scenario of modern human origins, than with the alternative hypothesis of essentially parallel, multiregional evolution within the different regions of the world.

The final, and perhaps most significant discovery which was claimed to argue specifically in favour of the population dispersal hypothesis emerged from the detailed work carried out on the patterns of mitochrondrial DNA variation in modern human populations in different regions of the world, undertaken by the late Allan C. Wilson and his colleagues at the University of California at Berkeley (e.g. Cann *et al.* 1987; Stoneking & Cann 1989; Wilson & Cann 1992). Basically, Wilson and his co-workers argued that modern human populations were far too similar in terms of their mitochondrial DNA makeup to be the products of largely independent evolution over a span of a million years or so, and must be the products of divergence from a single common ancestor at a much more recent period. Arguing that variations in mtDNA were most probably neutral in an adaptive sense and that the rate of mutation of mtDNA can be estimated from studies in other animal groups, they postulated that a common female ancestor had probably lived in the region of 200 ka ago (more broadly between *ca.* 50 and 350 ka), and that the descendants of this initial population had probably expanded to most other regions of the world by around 30–100 ka ago. Finally, they suggested that the geographical source of this common ancestor was most probably located somewhere in Africa. The latter conclusion was based partly on the demonstrably wider range of genetic variability apparent in modern African populations than among those in other parts of the world (suggesting a longer period of evolution of modern humans in this region than elsewhere) and partly on the construction of hypothetical trees of genetic descent by means of 'maximum parsimony' methods, all of which seemed to point to an African origin. At about the same time, similar claims for an apparently African origin were made by a number of workers based on analogous studies of the patterns of variation in 'classical' genetic markers, such as blood groups and proteins (e.g. Cavalli-Sforza *et al.* 1988), and by other workers based on variations in nuclear DNA in modern populations (e.g. Wainscoat *et al.* 1989; Lucotte 1989; Cavalli-Sforza 1991; Mountain *et al.*, this symposium). One of the most critical and controversial conclusions of the mtDNA studies was that the process of hypothetical population dispersal from the presumed African homeland appeared to have been achieved with no detectable interbreeding with the earlier, biologically 'archaic' populations within the different regions of Eurasia, and that these populations may therefore have become extinct without contributing any significant genetic legacy to the subsequent populations in the same regions (Stoneking & Cann 1989; Wilson & Cann 1992).

Reactions to these claims by proponents of the multiregional evolution school were swift, pointed, and forcefully argued (e.g. Wolpoff 1989; Thorne & Wolpoff 1992). Several workers pointed to the severe problems of estimating the rates of genetic divergence of mtDNA, and argued that by adopting rather different mutation rates (based, for example, on the assumption of an earlier date of divergence between the chimpanzee and human lineages, or earlier dates for the human colonization of the Americas and Australasia) one could recalibrate the date of the inferred common ancestor of all modern populations closer to one million years: that is, near the generally accepted date for the initial colonization of northern latitudes and eastern Asia by *Homo erectus* populations in the early Pleistocene. Further debate has centred on the methods of constructing the hypothetical genetic trees – particularly those involving the assumptions and methodology of 'maximum parsimony' approaches – a debate which flared up once again in the literature in the immediate run-up to the present symposium (e.g. Maddison 1991; Templeton 1992; Stoneking *et al.*, this symposium). If these objections are valid, then the presumed common ancestor of modern populations could potentially be located in almost any part of the Old World, rather than just Africa. Similarly, the implications of the skeletal remains themselves have become a topic of lively debate. Wolpoff, Thorne and others have argued that many of the current interpretations of individual skeletal remains (such as the recently discovered Neanderthal from Saint-Césaire) fail to make sufficient allowance for the probable degree of intrapopulation variability in Pleistocene hominids. More specifically, they have argued that the morphology of some of the relatively recent hominid remains from areas such as southeast Asia, Australasia and Central Europe, point strongly to a substantial element of morphological and genetic continuity between the 'archaic' and 'anatomically modern' populations in these regions (e.g. Wolpoff 1989; Thorne & Wolpoff 1992).

The spate of debate currently surrounding all of these issues in the origins and evolution of modern human populations served as a primary catalyst for the organization of the present meeting. The aim, essentially, has been to bring together a range of specialists in relevant scientific disciplines (i.e. evolutionary anatomy, molecular biology, archaeology, dating methods, etc.) to review the most recent discoveries and changing theoretical perspectives in these wide-ranging debates. The central theme of the meeting of course was to assess the specific bearing of recent advances in various scientific dating methods on the interpretation of these crucial formative phases in modern human evolution. It is this field of research which has made some of the most striking advances over the past decade, and which – as indicated in the preceding discussion – is now proving to be critical in the systematic testing of the various alternative models for the emergence of modern human populations.

The chronometric techniques primarily relevant to the topic of this volume (i.e. uranium-series, luminescence, electron spin resonance and amino acid racemization) provide dates for such materials as stalagmitic calcite, burnt flint, sediment, tooth enamel, and ostrich eggshells. Most of these techniques have reached the stage of application to the Palaeolithic comparatively recently, and the results so far achieved are only a foretaste of the full realization of their potential. The longer-established radiocarbon method unfortunately has an effective limit of around 40 ka (except in special circumstances) and hence only reaches into the later phases of modern human development, for which its datings of bone, teeth and charcoal are indeed of critical importance. At the other end of the timescale, in the dating of early hominids, the potassium-argon and fission-track techniques have been of even greater importance. Although the time-range of the former now extends into the Holocene, this method has not yet had significant impact on the issues under discussion here. This is because it is limited to circumstances in which there is chance association of human occupation with volcanic products (e.g. lava flows, air-fall deposits). Fuller discussion of these and other chronometric techniques will be found elsewhere (e.g. Aitken 1990).

Another important aspect of Palaeolithic chronology is the climatic framework within which sites are placed. Sites can be attributed to such climatic frameworks on several bases: (i) on their fossil flora, fauna and geological features; (ii) the characteristics of the associated archaeological assemblages; or, more recently, (iii) by direct chronometric dating. Initially, the climatic framework was in terms of the four major glaciations (Günz, Mindel, Riss and Würm) that had been recognized on the basis of geological evidence in the Alps; more complex regional frameworks were later evolved – for example, inclusion of warmish interstadials within the long glacial periods – with a correspondingly complex nomenclature. Fortunately a worldwide framework is now available. This is the oxygen-isotope stratigraphy, based on the climatic dependence of the ratio $^{18}O/^{16}O$ in marine fossil microfauna, studied in long cores obtained from the ocean floor; this ratio is used to define a succession of alternating cool and warm stages. The remanent magnetization of the terrigeneous component of the sediment cores allowed correlation of one stage with the most recent major geomagnetic polarity reversal observed in volcanic rocks, for which absolute dating has been provided by the potassium-argon technique; other stages were dated by assuming a constant rate of sedimentation, with further control provided by radiocarbon and uranium-series datings.

Latterly it has been established that there is good

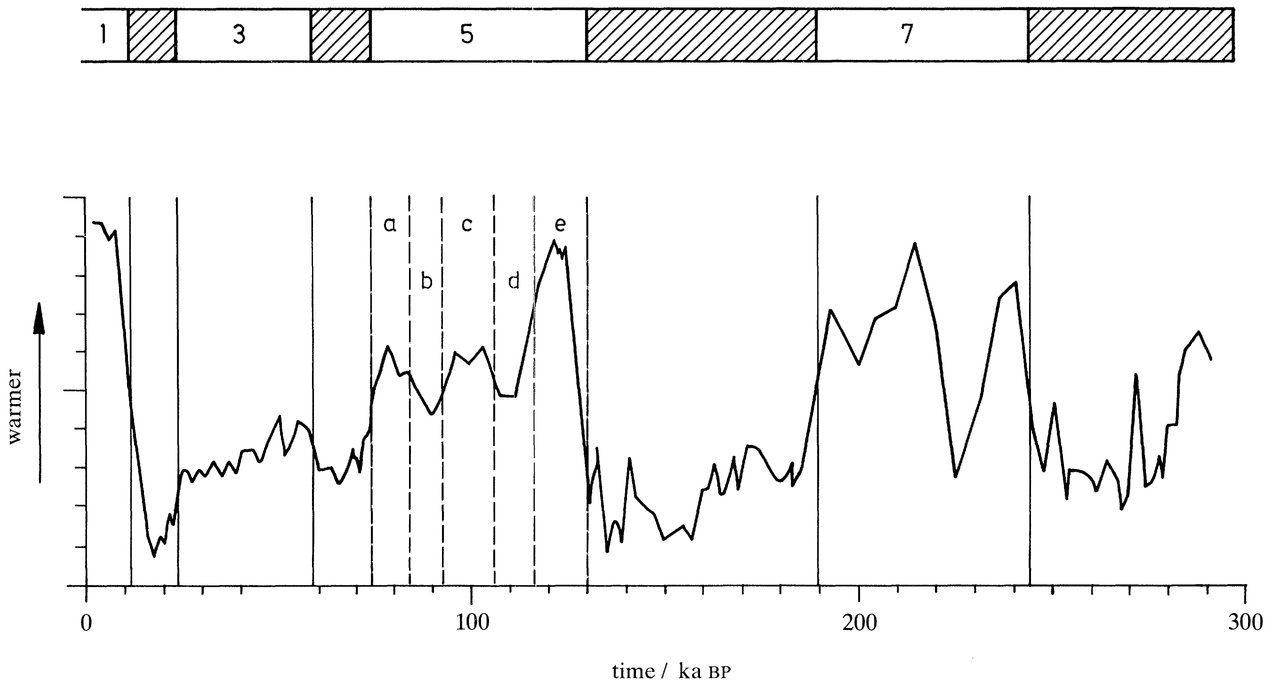

Figure 1. Oxygen-isotope variation for the past 300 ka with astronomically based timescale (redrawn, with additions, from Martinson *et al.* (1987)). The vertical axis represents changes in the averaged $^{18}O/^{16}O$ ratio found in benthic (bottom-living) foraminifera from five locations in the oceans of the world; five divisions equal a change of one part per thousand. Along the top the numbers allocated to warm stages are given, with intervening (even-numbered) cold stages being shown shaded. The letters (a, c, e) refer to warm substages of stage 5; there are intervening cool troughs, b and d.

correlation between the pattern of climatic variation so revealed and the Milankovitch astronomical predictions based on changes in the earth's orbital motion (eccentricity of the orbit around the sun; obliquity of the ecliptic; precession of the equinoxes); the changes result from gravitational perturbations due to the changing configuration of the planets. With this correlation established, the oxygen-isotope stages became datable with the same high accuracy as is possible for the orbital changes. In the context of the present symposium, the chronostratigraphy developed for the past 300 ka by Martinson *et al.* (1987) is of particular relevance. According to this (see figure 1) the penultimate major glaciation (stage 6) ended about 130 ka ago and the succeeding interglacial complex (stage 5) lasted until around 74 ka ago. The degree to which there is exact land–ocean synchroneity for all the detail revealed in the ocean sediments is the subject of continuing research, but the main features seem to be well reproduced on the continental land masses, thus giving a general chronological framework that is well dated in absolute terms. The isotope stages are now the fundamental time divisions of the Quaternary epoch.

Finally, it needs to be realized that although the new chronometric techniques mentioned earlier may be having a strong impact, there can be site-to-site variability in the reliability of results, and also that some sample types are not as satisfactory as others. Also, as some dating applications are made with the objective of exploring the performance of a technique in particular circumstances, it is important for a consumer to be aware of the pedigree of a date and to use restraint, if appropriate, in its utilization. For such discretion to be exercized it is necessary that the date should have been presented for publication in sufficient detail for assessment of its reliability to be made, at any rate by a specialist colleague; dates not so presented should be treated with caution, or ignored. Obviously it is advantageous if the consumer has familiarity with the dating method concerned, and one objective of the meeting on which this symposium is based was to encourage dialogue between consumer and dating specialist; hence the dating contributions which follow are addressed primarily to the non-specialist.

Note on dating terminology

The letters BP signify 'before present'. They have the strict connotation that the age quoted is given in radiocarbon years rather than calendar years; radiocarbon ages that have been converted into calendar years by calibration are given as cal BP. Most other techniques yield ages directly in calendar (i.e. 'sidereal') years and the letters BP are then inappropriate; in the case of amino acid dates based on calibration against radiocarbon, BP should be retained.

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